Chapter 6
Maintenance and Emergency Closure Facilities

6-1. Maintenance and Emergency Closure

a. General. Accidents involving the dam are usually caused by tows that have "broken up," resulting in barges being lodged in gate bays and/or wrapped around dam piers. Since bulkheads cannot be placed until the damaged barges are removed, and only one gate bay at a time can be closed using emergency closure, the practicability of bulkhead use and corresponding benefits are limited. The consequences of inoperable navigational dam gates may include loss of pool or higher than normal induced stages. Either event may involve significant economic losses. Measures to allow maintenance of dam gates and operating machinery, with analysis of the costs of providing emergency closure and the corresponding benefits (with water potentially flowing uncontrolled through a gate bay area), should be addressed in the design documents. Since access to spillway gates is usually via the closed lock gates, a contingency plan should be developed for access to spillway gates so closure can be made in case of an accident.

b. Spillway capacity. Limited gate availability operation occurs when one or more gate bays are closed for maintenance or repair work on the gates. The most important consideration in this operation is that the remaining spillway capacity should be sufficient to handle anticipated high flows without causing detrimental increase in upstream stages. If feasible, repair and maintenance work should be scheduled during low-flow periods. On some projects, locks could be used as floodways should an emergency develop during repair work if they have been designed and equipped for this purpose.

c. Emergency closure. Although emergency-closure bulkheads or vertical-lift gates are normally located upstream of the spillway gates, several instances of barges becoming lodged at the bulkhead location have precluded installation of the emergency closure. Consideration should be given to locations either upstream or downstream of the service gate to provide optimum protection. Potential for serious damage to a navigation dam exists due to the presence of navigation traffic. Appendix C includes descriptions of three major accidents that are representative of what can occur (Markland in 1967 and Maxwell in 1985 and 1990). In the case of collision, damage can vary from inconsequential to major, including loss of the navigational pool. Serious accidents are more likely to occur during high-water periods than during low water. Designers and operators should be aware of those conditions likely to cause serious damage to the structure in case of collision.

d. Spillway gate positions. For spillway gates, the two positions presenting the least potential for damage at many projects are the fully raised position, particularly if this is higher than barges or tows passing through gate bays, and the fully closed position. A particularly vulnerable position is that of the lips of the gates slightly below or slightly above water level. In a rising river situation, with consequent increasing gate openings, it should be required operating procedure that the gates be raised to a position above the highest expected water level. Designers may find it prudent to include remote operating capability to permit quick action on the part of operators during emergencies. In developing an operating plan, the responsible individuals may want to require a staggered gate operation in order to reduce the potential for a current concentration approaching the spillway (e.g., Gates 2, 4, and 6 should be raised one increment followed by raising Gates 1, 3, and 5).

6-2. Maintenance of Gated Nonnavigable Spillway Structures

a. Location. Maintenance of this type of structure is normally accomplished with the combined use of an upstream maintenance or emergency bulkhead and a downstream maintenance bulkhead (if necessary) to allow unwatering the gate (bay) during maintenance activities. Emergency closure equipment should be stored at the dam site. Downstream maintenance closures may be stored at the site or at a central location if used for several dams. Installation can involve the use of hoist cars, cranes, stiff-leg derricks, derrick boats, and in limited instances, divers.

b. Maintenance closure types. Since maintenance closure structures are for use when a spillway bay is to be unwatered for inspection or maintenance, they are designed only for static heads and cannot be installed in flowing water. Appropriate pier recesses and sills must be provided to allow for installation of these closure structures. The maintenance closure structure selected for use at a particular dam will depend on the type of gate and associated piers and sills, whether or not there are bulkheads available for use in the waterway system, what equipment or methods are readily available for use in transporting or installing the bulkheads, and economy and

reliability. The types of maintenance closures that have been used most are sectional bulkheads, dewatering boxes, vertical-lift gates, Poiree dams, and needle dams. Figure 6-1, *a-e*, shows these types of maintenance closures. Poiree dams and needle dams are generally not recommended because of the need to use divers to install them and the length of time required for the installation. Dewatering boxes are suitable only for wicket dams.

(1) Sectional bulkheads. This type of closure structure can be constructed of welded structural steel or riveted aluminum material. The limiting height of each individual section is governed by the handling capacity of the available handling equipment. Lifting beams or other provisions must be included. High-strength steels or aluminum can be used to lessen the weight of these bulkhead sections. Riveted aluminum bulkheads are in use on the 110-ft-wide lower Ohio River tainter gate structures because the bulkheads have to be transported from one dam to another and installed by a limited-lifting-capacity floating crane (derrick boat). These bulkheads are for use only downstream of the tainter gates; they are also used downstream at the locks. The maintenance bulkheads consist of trusses and skin plates or girders and skin plates. Wheels are not furnished on the ends since the bulkheads are installed in static water. The water load on the bulkheads is transferred to the pier walls at the pier wall recesses, and the sill carries only the dead weight of the bulkheads. Sectional bulkheads are used more than any other type of maintenance closure for ease of installation by floating plant.

(2) Poiree dams. Poiree dam closures are constructed of structural steel and are composed of a series of vertical A-frame truss members which are set and pinned by divers into an anchorage casting or shoe embedded in the concrete sill. When these members are positioned and properly stabilized, panels are placed on the upstream face of the A-frames. These panels are usually set by a derrick boat with the help of divers to position the underwater parts. Usually, one Poiree dam will be utilized for several dams in a waterway system. The water load on the Poiree dam is transferred by the A-frames to the concrete sill through the embedded anchorages. The Poiree dam arrangement is generally not selected for new designs because better, safer options are now available.

(3) Needle dams. Needle dams are constructed of structural steel and are composed of a horizontal beam or girder or triangular truss supported by the piers at each end and a series of needles or vertical panels that rest against the support at the top. These needles are positioned by a diver into the proper location on the concrete sill at the bottom. Thus, a portion of the load is transferred into the pier recesses at the top, and a portion of the load goes into the sill from each individual needle or panel. A pipe or similar object is positioned at each of the abutting edges of the vertical panels to better seal the opening. For further watertightness, cinders are sometimes used. This type of closure is more suitable for narrow gates because the needle beam weight and configuration become limiting factors. Needle dams are adaptable for either upstream or downstream closures. As with the Poiree dam, this arrangement is generally not used for new designs.

(4) Floating closure. Floating closure structures have not been used extensively, but where they have been used they have functioned well. One such caisson is used for locks on the Columbia and Snake River systems. Another floating caisson is in use for 110-ft-wide locks on the Tennessee and Cumberland River Waterways. The structural steel caissons are composed of watertight compartments which allow the towing of the floating caisson from one lock to another. The compartments are filled with water so that the caisson can be positioned in recesses in the lock wall and sunk in place across the lock chamber. Compressed air is used to remove the water from the caisson and return it to floating capability. In view of the success of these facilities, a floating caisson is feasible.

(5) Braced-box cofferdam. A large braced-box cofferdam, constructed and installed as two halves (to facilitate use of an existing 100-ton derrick boat), was successfully utilized to repair the Ohio River Lock and Dam 52 temporary lock (cellular/concrete) miter gate sill.

(6) Use of emergency closures for maintenance closures. At dams where an emergency closure structure is provided upstream of the service gate, the emergency structure can also be used for maintenance unwatering. Additionally, recesses can be provided in the piers for installation of sectional bulkheads similar to the ones used for unwatering maintenance downstream of the gate.

6-3. Emergency Closure of Gated, Nonnavigable Spillway Structures

Where a large level of damage could result from water flowing free through a dam gate bay, an emergency means to quickly stop the unrestricted flow should be studied. This unrestricted flow could happen if the gates were rendered inoperable or knocked out due to being rammed by a tow.

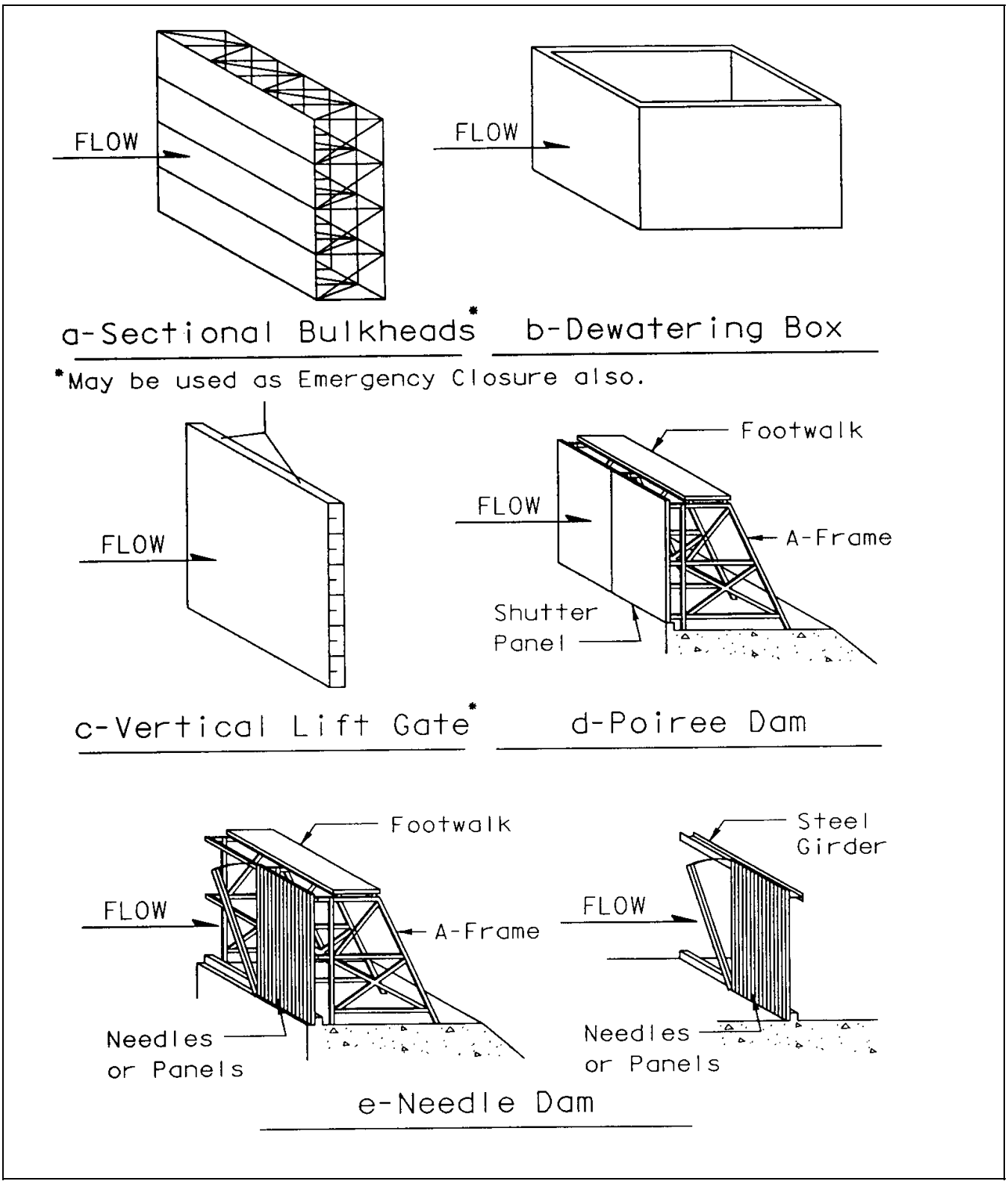

Figure 6-1. Maintenance closures

a. General. The following conditions must be considered and evaluated in determining whether or not an emergency closure structure is necessary: consequences of loss of pool (such as effects on water intake and outfall structures and docks and towing industry losses); economic losses to shipping interests due to halt of river traffic; possible flood damage and danger to people downstream; and consequences to channel banks in pool due to sudden drawdown. If incorporation of emergency closure is found to be economically justified, all elements of the emergency closure structure, including the handling equipment and machinery and the structure itself, should be ready for use 24 hours a day. Proper maintenance of all elements is necessary, along with periodic practice installation of the closure. Reliability and a fast installation time are a must. The types of emergency closures that have been used are stacked bulkheads and vertical-lift gates.

b. Overhead stacked bulkheads.

(1) General. The stacked bulkhead arrangement has proven to be the most dependable and reliable for emergency closure purposes. Most major dams built in recent years have utilized this concept successfully. The sectional bulkheads (stop logs) have end rollers and are made up of trusses and skin plates. The lifting and installation equipment is usually very expensive and consists of either a bridge crane (hoist car) or a traveling gantry crane.

(2) Bridge crane (hoist car). The bridge crane (hoist car) is sometimes referred to as a locomotive crane. See Plate 9. Most of the tainter-gated dams on the Ohio River and the new Melvin Price Locks and Dam on the Mississippi River use a bridge crane for handling the bulkheads. At many of these projects, the spillway bays and the lock width are both 110 ft wide so that the emergency bulkheads can be used to close off either an individual 110-ft-wide spillway bay or one 110-ft-wide lock chamber. Thus, the service bridge is laid out so that it and the bridge crane and bulkheads serve both the locks and dam spillways. An auxiliary crane is located on top of the bridge crane for use in handling small loads during maintenance or unwatering activities.

(3) Detailed bulkhead installation procedure. Past experience and model testing by WES have shown that bulkheads cannot be lowered safely one at a time in flowing water. Therefore, the stacked bulkhead system was developed so that the flowing water never goes over the top of the bulkheads.

(a) The Ohio River and Mississippi River Dams mentioned above have a hoist car mounted on rails on a service bridge which serves both the dam spillway and the locks. Normally, the bulkheads are stored singly over the spillway bays on retractable dogging devices on the service bridge piers. The required lifting beam will be stored on one of the dogged bulkheads. The hoist car can travel the full length of the service bridge but can carry only the lifting beam and one bulkhead while traveling.

(b) The following example details the installation procedure for three bulkheads; however, the same sequence of activities would be true for any number of bulkheads. The hoist car will pick up one bulkhead with a lifting beam and move it to the location for unwatering; at this location it will be placed on the dogging device. The hoist car will then move with the lifting beam and pick up another bulkhead and move back and place it atop and latch it to the first one. The two will then be raised enough to retract and reposition the dogging device so that they can be lowered onto it. The hoist car moves with the lifting beam to get a third bulkhead, which is placed and latched to the other two, and then lifts the three bulkheads and lowers them as a unit into the flowing water after the dogging device has been retracted. In this manner, the flowing water is stopped without being allowed to flow over the top of any of the bulkheads. After the bulkheads have served their purpose and the spillway gate is closed, the bulkheads are removed one at a time in a balanced (static) pool situation by the hoist car and returned to their individually dogged (stored) position.

c. Vertical-lift gates. Vertical-lift gates may also be utilized as an emergency closure--especially on dams that have vertical-lift spillway service gates which are installed and removed by a traveling gantry crane. These gates would be similar to the vertical-lift service gates described in paragraph 5-2*c*.

6-4. Maintenance of Gated, Navigable Spillways

Maintenance of gated navigable spillways must be accomplished under somewhat different conditions than that of nonnavigable spillways. The absence of intermediate piers generally limits the type of closure to floating bulkheads, rigid-box closures, Poiree dams, separate duplicate gates, collapsible A-Frame, and, for low-head applications, removable-post and stop-log installations. The gated navigable pass spillway is generally less vulnerable to navigation accidents than nonnavigable spillways because the gates are lowered during high water events,

which produce conditions most likely to lead to an accident.

Also, since a damaged navigable pass gate is usually comparatively small, and redundant operating procedures are easily accommodated, an emergency gate for this type of spillway is generally excluded.

a. Machinery. Machinery for gated navigable spillways, which can be incorporated in a dry gallery in the dam sill, is much easier to maintain than machinery for nonnavigable spillways. Also, because navigable pass gates are generally smaller, gate and operator units (cylinders) which can be easily removed and replaced by spare units are desirable. This shortens exposure time and lessens the difficulty of normal maintenance by allowing offsite rehabilitation of the major units. Use of various caissons, floating bulkheads, and gates for maintenance of gated, navigable spillways is similar to that described for nonnavigable spillways, with the exception that spillway piers are absent. The procedure utilized for maintenance will rely on a floating plant, which must be included in the maintenance scheme unless duplicate gates are used as backup to the service gates.

b. Procedure. At the Olmsted Locks and Dam project, the procedure for performing maintenance will be accomplished with the use of a one-piece shutter box, which allows work on one, two, or three gates at one setting. The upstream shutter box will be placed any time work is required on a wicket. With the box in place, any "in-the-wet" work can be done. The water level within the box will be the lower pool level. A brace will be provided to prop a wicket vertically, if desired. The downstream shutter box is required when it is necessary to dewater the area. At the top, a truss may be provided to carry the loading.

c. Maintenance. Maintenance of the hydraulic system will be performed by removing the entire hydraulic system (cylinders, flexible lines, bearings, cover seal, rubber boot, etc.) from the precast frame in the sill. The unit will be removed by personnel on the work boat and a new or refurbished one inserted. This will allow the unit to be refurbished for future use in the maintenance shop as time permits. The hydraulic pumps and valves will have shutoff valves and unions to allow removal of any component from the dry gallery. The hydraulic lines which penetrate the gallery walls will be located inside a sleeve for replacement when the hydraulic cylinders are removed. The wickets will be pinned in place, and the hurters will be bolted down. These items will be removed by the personnel on the work boat.

6-5. Emergency Closure of a Gated, Navigable Spillway

As stated earlier, if flow conditions and redundant (backup) systems of operation are incorporated (and loss of pool is a low-risk occurrence), then emergency closure may not be required. An example of this is included in the Olmsted project. At this project, all of the dam wicket gates will be required to be up only during a very infrequent low-flow event. Damage to a significant portion of the dam can be tolerated (temporarily) by shifting regulation from damaged gates to unused (down) gates. Risk of loss of pool is low, and repair may then be accomplished with more favorable upper and lower pool conditions. Additionally, the wicket gate operating systems may be switched over to the adjacent bank of pumps and motors in the event of failure of one system.

a. Crane operation. The wickets are also designed to be raised and lowered by a crane located on a work boat. In addition to raising and lowering a wicket if the hydraulic system is inoperable, the crane will cut away large debris that collects on the dam by means of a hydraulic shear attachment on its boom, set the shutter boxes, and remove components of the navigable pass such as wickets, cylinders, and hurters. The wickets will use the same basic principle of prop and hurter mechanism used at Locks and Dams 52 and 53 on the Ohio River. The major addition to the prop is the installation of a "weak link" to be used to help prevent serious damage to the wicket during a navigational accident. The prop will be designed to withstand ice and impact loading but to fail and allow the wicket to fall when impacted by a load slightly below the yield strength of the wicket.

b. Further requirements. If emergency closure of a gated navigable pass spillway is required, a floating bulkhead structure with adequate guide and anchorage must be provided, or a separate set of gates must be provided with the appropriate lengthening of the dam sill to accommodate these gates (which are generally upstream of the service gates).

6-6. Maintenance and Emergency Closure of a Fixed-Crest Spillway

Special provisions for fixed-crest spillways are not normally required because of the low risk and low maintenance requirements.

6-7. Floating Plant

a. The floating plant necessary for installing the upstream and downstream spillway gate bay unwatering bulkheads for either maintenance or emergency purposes may be composed of the following:

(1) Derrick boat with suitable capacity and reach.

(2) Work barge to transport sectional bulkheads from storage location to dam spillway.

(3) Work (shop) barge with all necessary equipment such as anchor lines, tools, paint, ladders, sand blasting equipment, safety harness, etc.

(4) Personnel barge with clothing-change facilities for special body covering and footwear plus eating and break accommodations, if not provided on shop barge.

(5) Small boat with outboard motor for transporting personnel to and from bank to work barges and personnel barge.

(6) Work flat (approx. 8 ft × 12 ft).

b. To stabilize all the above floating plant vessels in suitable locations above and below the dam in flowing or quiet water situations, it is necessary to furnish mooring rings, check posts, and line hooks on each pier, and armored mooring holes through the piers to use to anchor lines from the floating plant vessels. For emergency situations, such as free flow through a spillway bay when a spillway gate cannot be closed for some reason, it will be necessary to provide additional anchorage facilities upstream of the dam. These facilities can include dead-men, mooring cells, or pylons on the bank or in the water, and mooring posts on the upper lock wall--all to accommodate floating plant anchor lines.

6-8. Galleries, Adits, and Openings

Normal periodic maintenance and inspection of spillway gates, when the gates are not unwatered, can require providing a means for operating personnel to access certain parts of the gate. This is particularly true for a tainter gate. The dam pier will usually contain a stairwell extending from the service bridge level down to the trunnion girder level. An opening from this stairwell to the trunnion girder on the downstream face of the pier will provide personnel access for greasing the trunnion pin and for inspecting the trunnion anchorage and the trunnion girder. Some tainter gate arms also have hand-rails for personnel use in accessing the gate body. Also, an access opening may be provided from the stairwell to the spillway face of the pier for wire rope greasing and inspection and gate inspection. For double-skin plate gates and gates with cover plates, this type of opening can allow access to the interior of the gate.